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Technology Evaluation of Process Configurations for Second Generation Bioethanol Production using Dynamic Model-Based Simulations

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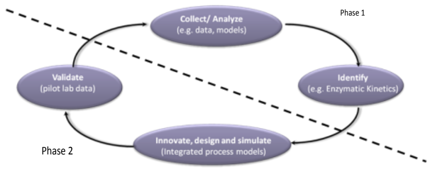
Introduction

Bioethanol production involves a number of unit operations such as, pretreatment, enzymatic hydrolysis, co-fermentation, downstream processes. Currently the transfer of these processes from proof-of-concept to industrial scale has been mainly done on an empirical and experimental basis that might be inefficient and costly in terms of times and resources consumption. This study considers the use of a dynamic model-based simulation framework to identify optimal process configurations for improved bioethanol production from lignocellulosic feedstock.

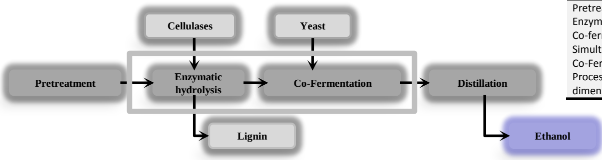
Objective:

Technology evaluation for optimal process configurations for bioethanol production using a dynamic model-based simulation framework.

Dynamic Model-Based Simulation Framework



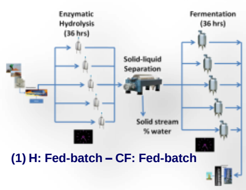
1) Collection, analysis and identification: reliable dynamic mathematical models for the different unit operations



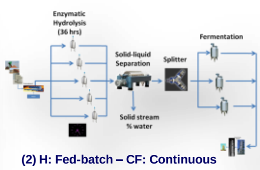
Pretreatement	Lavarack et al. (2002)
Enzymatic Hydrolysis	Kadam et al. (2004)
Co-fermentation	Krishnan et al. (1999)
Simultaneous Saccharification and Co-Fermentation	In house model
Process conditions and unit dimensions	NREL report (2002)

2) Design, innovation and simulations: novel process configurations (fed-batch, continuous and continuous with recycle).

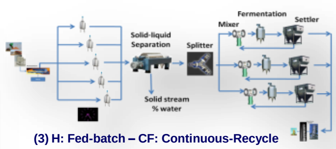
Morales-Rodriguez et al. (2010)



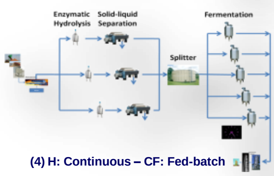
(1) H: Fed-batch – CF: Fed-batch



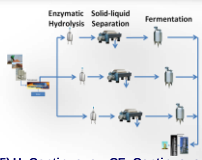
(2) H: Fed-batch – CF: Continuous



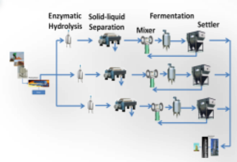
(3) H: Fed-batch – CF: Continuous-Recycle



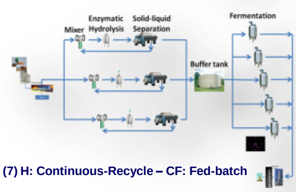
(4) H: Continuous – CF: Fed-batch



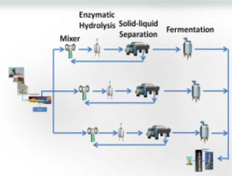
(5) H: Continuous – CF: Continuous



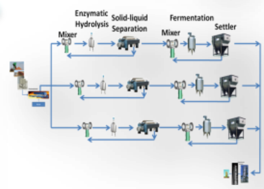
(6) H: Continuous – CF: Continuous-Recycle



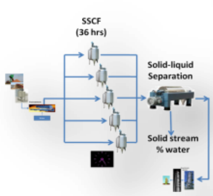
(7) H: Continuous-Recycle – CF: Fed-batch



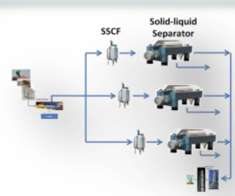
(8) H: Continuous-Recycle – CF: Continuous



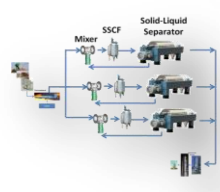
(9) H: Continuous-Recycle – CF: Continuous-Recycle



(10) SSCF: Fed-batch



(11) SSCF: Continuous



(12) SSCF: Continuous-Recycle

H = Enzymatic Hydrolysis

CF = Co-Fermentation

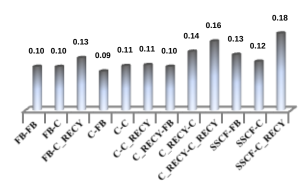
SSCF = Simultaneous Saccharification and Co-Fermentation

Which is the best process configuration?

Benchmarking Criteria

Ethanol/dry-biomass ratio:

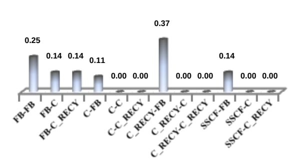
$$R_{Et/dry-biomass} = \frac{Total\ Mass\_Et}{Total\ Mass\ Dry\_Biomass}$$



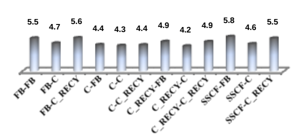
Unprocessed raw material:

$$URM = \frac{ADB + Solid\ stream\ from\ S\text{-}L\ separator}{Total\ Mass\ Dry\_Biomass}$$

ADB: Accumulated Dry-Biomass



Ethanol concentration:



Discussion and Concluding Remarks

- 12 novel process configurations for cellulosic bioethanol production have been analyzed . The main findings are:
  - Recycling in general has a positive effect on the ethanol yield.
  - The best configuration: continuous SSCF with recycle
  - Ethanol yield of 0.18 kg/kg-dry biomass could be obtained. This is a significant improvement compared with the NREL configuration (three-folds).
- Pilot plant validation of these promising results is recommended.

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